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ECONOMIC TRADE-OFFS IN AIR POLLUTION ABATEMENT

*By Bruce C. Netscher**

*"Just such disparity
As is 'twixt air and Angels' purity. . . ."*
JOHN DONNE

Pollution is an ugly word and air pollution is something we instinctively abhor. None of us, however, is free from sin on this score, for we are polluters, one and all, even if we don't drive or smoke. Nevertheless, polluters though we may be, it is safe to say that no one is for air pollution. It is not like water fluoridation or, to use an economic example, like the protective tariff, on which there is a clear division of opinion. Rather, pollution abatement is like education; there is universal agreement that it is a Good Thing. This being so, the ubiquitous observer from Mars might well wonder what all the commotion is about. Why don't we get on with it and just abolish the nuisance—pass a law forbidding air pollution?

This was, in fact, tried a while back. Edward I of England forbade the use of "sea coal" in London in the 14th Century in an attempt to eliminate the smoke problem, with the death penalty for repeated offenses. The success of this attempt is indicated by the fact that Elizabeth I, almost 200 years later, also felt compelled to proclaim coal-burning illegal. The lack of her success was even more conspicuous.

What these English rulers came up against was, in effect, not far different from what faced one of their predecessors, King Canute. Although not a natural force, it might as well be one. To say that we are all polluters is facetious and gets us nowhere. There is, however, no facetiousness in the statement that our society cannot exist without creating pollution. It is even less possible today to eliminate pollution than it was for Edward and

Elizabeth to eliminate the burning of coal. The best we can do is lessen it.

Not only is some pollution inevitable, but the economist, in his usual dismal fashion, concludes that in the absence of specific social action to the contrary the mess we now find ourselves in was also inevitable. The "invisible hand" of classical economics, the market mechanism on which we still basically rely, is imperfect and, as in numerous other instances, is unable by itself to bring about the social optimum. The costs resulting from each individual act of air pollution are not incurred by the emitter, but by society as a whole. Thus, since the emission is costless to the emitter, there is no economic motive for him to do anything about it. In the jargon of economics costs are sometimes referred to as "diseconomies," and social costs, since they are not incurred by the individual economic activity responsible for them, are termed "external diseconomies" or "externalities." In short, then, the costs of air pollution are externalities and because of this pollution tends to grow *ad infinitum* in the absence of social action to curtail it.

This brings us up against another inevitability. If we assume that polluters in general are behaving in an economically rational fashion—a not unreasonable generality—it follows that the polluting activity of each is associated with minimization of his costs: if he could have reduced his costs by curtailing or eliminating his emissions, he would have done so. This means that if his polluting is to be curtailed or eliminated, it will involve costs. Pollution abatement cannot be done free and we have, as a result, the first trade-off. As in all economic choices, we must balance what we would like to have against what it will cost, and air pollution abatement itself is an economic trade-off for society as a whole.¹

Since it is neither possible nor desirable to attain the good Dr. Donne's "angels' purity," it is necessary first to define the ultimate goal or limit of air pollution abatement beyond which it would make no sense to pursue abatement further. In the last analysis, this goal is the threshold level, the demarcation between pollution in the meaningful sense and what is conveniently described by the oxymoron, "non-polluting contamination." In this respect there is a similarity to another environmental "pollutant," radioactivity—there is a natural background level from which we could, if we desired, isolate ourselves, but to do so

would be inherently wasteful of our time and resources. There is further similarity in the matter of threshold exposure and the complications of instantaneous and cumulative doses. As we know, the question of the threshold in establishing radioactivity safety levels has generated a good deal of incandescent argument in health physics, and here, too, there is a parallel in air pollution. In many instances, especially the sulfur oxides, the threshold concentration which produces adverse physiological effects is still a matter of great controversy.

In any event, within that limit, whatever it is, we must next establish a working goal toward which to aim our abatement efforts. Now we are really in the realm of economic trade-offs, for there is only one way in which we can make this decision and that is to compare the value of what we obtain with the cost of obtaining it. In the most general sense this is what is involved in any economic decision, made by anyone. To the economist it also suggests "cost-benefit analysis," the approach developed for similar decision-making where social costs are involved, as in flood control, for example. The costs of the proposed action (decision) are added up, a value is computed for the benefits, and if the latter exceeds the former there is, *ipso facto*, economic justification. In air pollution abatement, where there is a wide range of possibly justifiable actions, the cost-benefit approach offers the added advantage of determining the best action in terms of the optimal cost-benefit relationship.

THE COST SIDE OF THE EQUATION

Cost-benefit analysis has been developed into an elaborate technique in the justification of large public works such as dams, harbor improvements and the like. One of the problems in applying it to air pollution decision-making, however, is the far greater complexity of choices and the potentially wide ramifications of any particular choice. Consider, as an example, the reduction of sulfur oxide pollution from central power stations, one of the aspects of air pollution that has been emphasized in control programs to date.

The approach that has been adopted in New York City to deal with this problem has been to set a standard for the maximum sulfur content of the fuel that is burned. If the fuel user desires to continue to burn the same type of fuel as before (i.e., coal or oil), he can meet this standard in a number of ways: by

using fuel in which the naturally occurring sulfur content is low enough to meet the standard, by desulfurizing the fuel so that it meets the standard, by blending high-sulfur fuel with low-sulfur fuel, or by any combination of these. Now it happens that the supply of coal and oil with high sulfur content is greater than that with low sulfur content, so that the price is lower, and this, of course, is why it was being used to begin with. Obviously, then, compliance with the air pollution standards means higher fuel costs, which are ultimately passed on to the consumer.

It would appear to be a simple matter to take the difference between the high-sulfur fuel cost and low-sulfur fuel cost as the measure of the cost of the control program to society. There is much more to it than that, however. If the user decision is to go to foreign sources of naturally low-sulfur fuel oil, it means that African oil rather than the Venezuelan oil which previously constituted the chief supply. The result could be a net shift in the balance of payments position of the United States, since Venezuelan oil can be desulfurized either in the Caribbean or in this country. This balance of payments effect, as well as such non-economic aspects as the implications for our international relations must be included in the cost calculation. With desulfurization, the refiner also has a choice, over a wide range of proportions, between producing fuel oil or other, more valuable petroleum products. The desulfurization cost itself may therefore be difficult to determine, since it may not be fully reflected in price.

The difficulties of costing this particular means of air pollution control are compounded, moreover, by the fact that the control decision is necessarily an *ex ante* one; it is before the fact. There is no way of forecasting accurately, beforehand, which alternative or combination of alternatives the fuel users will choose. It might appear to be a straightforward matter of comparing the costs of the various alternatives and assuming that the fuel users, being economically rational, will choose the lowest cost one. This assumes, however, that the judgment of the fuel users and the pollution control authorities on the relative costs will be the same. In the case of the New York pollution control program the problem was even worse: no desulfurization capacity existed and it was impossible to guess how much would be installed as a result of the program if, indeed, any would be.

But these difficulties pale beside those associated with the cost-benefit determination on coal. Sulfur exists in coal in both

organic and inorganic form. Removal of most of the inorganic sulfur is technically feasible and is normally accomplished as part of the preparation of coal for the market (although not necessarily for the specific purpose of desulfurization). Removal of the organic sulfur, however, is economically infeasible at present and there is no foreseeable prospect for feasibility.

The ultimate standard established by New York City is a maximum 1 percent sulfur content in the fuel burned. A Bureau of Mines survey of 1964 coal production showed that 62 percent of the total U.S. production had a sulfur content of greater than 1 percent. This production involved 70,000 miners, or 55 percent of the total mine labor force. In six producing states (Pennsylvania, Ohio, Illinois, Indiana, Missouri and Western Kentucky) all of the output was coal with more than 1 percent sulfur, and these states accounted for 37 percent of the total mine labor force. Low sulfur content is a premium quality in the metallurgical use of coal, and three-quarters of the 1964 production of low-sulfur coal was for this use, both domestically and in the export market.²

It is clear from this that the cost of the New York City control program, if properly measured, would have to take into account the expected adverse effect on the economy of the coal districts supplying coal to New York City as well as the balance of payments effect if it were assumed low-sulfur coal were used in the City instead of exported.

There is also another user alternative—the use of other fuels. Natural gas is sulfur free. Like the cost of coal and oil, its cost to utilities is published information, so the difference in cost can be directly compared. Again, however, such direct comparison is insufficient. The imposition of a sudden, sizeable increment of demand in the market for gas may well have its own effect on the price of gas.³ This effect will depend on the supply characteristics of the gas industry, and any price changes would, in turn, have effects on the demand for gas by various types of customers. It is necessary, therefore, to consider the elasticity of both gas demand and gas supply in considering the cost of a shift to gas. (There are difficulties here, too, but this is a matter economists prefer to discuss among themselves.)

The utility fuel user can also go nuclear, although this is possible only for new plants. In the opinion of some, this would not be a cost, but a benefit. This point will not be argued, except

to note two things: (a) nuclear cost figures in recent months have exhibited a volatility more appropriate to the high flyers of Wall Street; and (b) one of the costs of avoiding air pollution via the nuclear route can be an increase in the thermal pollution of our water resources. In any event, the significance of the nuclear option is that the nuclear-fossil fuel comparison must be made in determining the cost side of the cost-benefit equation.

Similarly, the utility has the option in new plants of placing them outside the urban area and thereby (hopefully) escaping the sulfur limitation. It can be assumed that this also would definitely incur costs, since if it did not, it would have already have been made. And these costs, too, must be taken into account.

At this point the stage shifts. We have been discussing alternatives facing the fuel user in meeting an air pollution control standard limiting the sulfur content of fuels burned. But it should be borne in mind that such a limitation is a means to an end, not an end in itself. The goal of reduced sulfur pollution can be sought by other means, which constitute alternatives available to the control authority. One such alternative is desulfurization of the stack gases resulting from combustion. This has the advantage of requiring the investment to be made directly by the emitter rather than externally (as in fuel oil desulfurization). The cost of pollution abatement here is the addition to the unit cost of power being generated.

Once again, despite appearances, the costing is not a simple matter (at least, as yet). Stack gas desulfurization is still in the experimental stage, and it is not at all clear which of the many processes being tested will be best, and under what circumstances. Much has been made of the fact that by using fuel of sufficiently *high* sulfur content stack gas desulfurization could be made costless or even profitable through the sale of the recovered sulfur or sulfuric acid. It has been pointed out, however, that if only one-half of the sulfur emitted in the combustion of coal and oil in this country were recovered in the form of elemental sulfur, it would increase domestic sulfur production by one-third; if the sulfur were recovered as SO_2 it would provide a quantity of sulfuric acid almost equal to the total annual domestic consumption of that commodity.⁴

A second alternative to limitations on the sulfur content of fuels is the high stack. The concept of the high stack as a means

of SO_x pollution abatement is based on the distinction between the SO_x concentration in emissions and ambient air concentration. This proposition is valid, however, only if it is true that through the use of high stacks, high emission levels will not result in high ambient levels. This is another area in which controversy is sharp, mainly because there are simply not enough empirical data on which to base policy. High stacks are being built, nevertheless (the newest one is over 1,200 feet tall), and with sufficient experience it should become clear whether dispersion can be counted on to offset high emission levels.

The foregoing demonstrates that on the cost side of the cost-benefit calculation the problem is one of complexity plus an inadequate empirical basis. Small wonder, then, that an inter-departmental committee of the Federal Government concluded, after investigating abatement costs at the national level, "... there are no acceptable national estimates of total investment or annual cost."⁵

THE BENEFIT SIDE OF THE EQUATION

Let us turn now to the benefit side of the equation. The problem here is to measure, in dollar terms, the benefits resulting from the abatement action. Unfortunately, there is no direct means of doing this: what is the value of clean air, as such? The best that can be done is to use the costs incurred because of pollution; in economic terms, the "opportunity cost" of pollution abatement. If, due to pollution, a person spends \$X, the value to him of an abatement program which eliminates that expense is those same \$X, and this also holds true, of course, at the level of society as a whole. Pollution, however, is not a one-time thing but is continuous, so that there is not a single expense but a stream of expenses. The appropriate measure is therefore the total of those expenses over the appropriate time period, discounted at an appropriate rate.

As a theory this approach is impeccable, but as a practical means of measurement its usefulness is woefully limited.⁶ For example, a New York State air pollution official has estimated that residents of New York City would save \$800 million per year, or \$50 per capita, in cleaning costs for clothing, homes and vehicles, if the State pollution criteria were attained.⁷ On the other hand, figures presented by a staff member of the National Center for Air Pollution Control indicate that for the United

States as a whole the cleaning cost attributable to air pollution is in the neighborhood of \$2.9 billion.⁸ It is well known that New York City air is dirty, but it is unlikely that it is responsible for over one-quarter of the total cleaning bills of the United States attributable to air pollution. Obviously, one or the other of these figures is implausible, and given the crudity of the basic statistics from which they were derived, both of them are of doubtful validity. It is far from certain that they even represent the correct orders of magnitude.

On another score, attempts have made to correlate property values with air pollution. It is evident that, other things being equal, a lot immediately downwind from a rendering plant will have a lower value than a lot five miles on the other side. But this is no help. Nor is it much help to know, from the findings of a regression analysis of sulfur trioxide levels and property values in the St. Louis Metropolitan Area, that there is a decrease in property values of \$245 for every increase of 0.5 milligrams of sulfur trioxide per 100 square centimeters per day.⁹ Such precision belies the fact that no multiple regression analysis can adequately deal with the complex relationships of the many variables involved, much less the psychological factors.

It is the latter, indeed, that stop measurement in its tracks. How is one to measure the health benefits of pollution abatement (assuming we can ever reach agreement on the health *effects* of pollution), or the esthetic values created by abatement? Granted, one could, after the fact, compare medical and hospital costs in a polluted area before and after abatement, but what are such values compared with the value to the individual of his improved health? We are in the realm of the wholly subjective, and until we possess some of the instruments of science fiction we must be content with frustration.

USEFULNESS OF COST-BENEFIT ANALYSIS

We have, then, two wholly different problems on the two sides of cost-benefit analysis. On the cost side we are led into a multiplicity of trade-offs, each of which must be explored if we are to make our decisions with maximum objectivity and which call for better data than have thus far been available. On the benefit side we are faced with formidable, if not wholly intractable measurement difficulties. Does this mean it is fruitless to use the cost-benefit approach, even if it is the only tool we have for

approximating rational decision-making? I do not think so, but before developing this point let us turn to a later stage in the process of air pollution abatement, the choice of regulatory criteria and the tools of regulation.

REGULATION

It is important to recognize that the choice of criteria itself involves trade-offs which, although they may not be strictly economic, have economic implications. The relevant criteria are the ambient air standards which are the goal of the regulation and the maximum level of emissions permitted. Compare, for example, the ambient air SO₂ concentration criteria in the following jurisdictions (all concentrations are by volume):

St. Louis Metropolitan Area:

0.25 ppm for 5 minutes, once in any 8 hours

0.10 ppm for 1 hour, once in any 4 days

0.05 ppm for over 24 hours, once in any 90 days

San Francisco Bay Area:

1.5 ppm for 3 minutes during the daytime, 6 minutes during 24 hours

1

1 (14 intermediate categories, by 0.1 ppm steps)

1

1

1

0.3 ppm for 8 hours during the daytime, 16 hours during 24 hours

State of Colorado:

0.5 ppm for one hour

0.1 ppm for 24 hours

There is, as can be seen, a wide variation in levels, duration and frequency in the various criteria, which is not surprising, since one would expect that the criteria would differ for different areas, each of which has its peculiar circumstances. The significance of the figures in the present context is their indication of the almost infinite number of combinations of level, duration and frequency that is possible, and each combination has its own trade-off, or cost-benefit relationship. It is not clear how any of the listed criteria were arrived at, but probably not much consideration was given to the trade-off aspects of the choice. To the extent this is true our air pollution regulators may not only be making implicit or unrecognized trade-offs on the wrong

terms, the trade-offs may be the wrong ones. The possibility becomes stronger, moreover, when the choice of criteria is widened to include not only ambient air levels but emission levels (without relating them to ambient air levels) and limitations on the sulfur content of fuels.

This is not to suggest that a marginal analysis in cost-benefit terms should be undertaken to determine which criteria constitute the optimum trade-off of costs and benefits. Indeed, such a suggestion would be difficult to make in view of the emphasis which has been placed on the lack of data. It is suggested, however, that at the very least the authorities should be aware that they are engaged in trade-offs in the establishment of criteria, and would hope that within the limits of the imperfect knowledge of both costs and benefits their choice of criteria would represent balanced judgment rather than arbitrary discretion. It would be even more unfortunate if the authorities were to become wedded to initially established criteria when there is still great uncertainty with respect to their validity as pollution indicators, not to mention their efficacy as regulatory standards. It is also hoped, therefore, that established policy does not become dogma, and that the policy-makers will keep a continuing review under way and will be flexible enough to change policy if and when such a course is indicated.

But there is still more to the catalog. Beyond the choice of the standard or standards there is the option in the ways in which they may be applied. Should standards apply without discrimination, for example, or should there be some proportionality (or even disproportionality), depending on the degree of emission and/or its harmfulness? The interdepartmental committee mentioned above investigated this matter with simulation models. One model, of a hypothetical city of two million population, indicated that the cost of attaining an assumed pollution standard (60–75 percent reduction of human exposure to SO_x and particulates), by requiring abatement only by those emitting harmful wastes and able to achieve abatement of those wastes, would be three-fifths of the cost of requiring all emitters to reduce their discharges by the same proportion. A second model, covering the central power stations in 20 cities with the worst SO_x problem, indicated that by taking into account the prevailing winds and the compass location of plants, and applying the standards on sulfur content of fuel used only to those plants in

the prevailing wind quadrant, the additional fuel cost incurred by pollution abatement would be only one-eighth of the cost if the standards were applied to all plants.¹⁰

Again it behooves us, in the light of what has been said, to observe that no faith should be put in the actual numbers yielded by the models in view of the statistical deficiencies alluded to and the compounding of assumptions within the models. Ignoring the actual levels, however, the numbers suggest that significant cost differences can result from different applications of a given standard. Since the choice exists with a given standard, the trade-off in this instance is not between the costs and the abatement results. Instead, it is a balancing of the costs imposed by the different methods of application and the costs of administering those methods. Thus, in the case of the single-city model one would expect, *a priori*, that across-the-board administration of a given emission standard would be less costly than selective administration. But the simpler administrative scheme involves higher costs to the polluters, hence to the public. The trade-off, therefore, is all on the cost side, and the optimum solution can be described, somewhat tautologically, as the "least-cost cost combination."

TAX INCENTIVES

Let us look at one last example. It has been emphasized that all abatement involves costs. As an alternative to the imposition of standards and the resulting ultimate imposition of costs on the public in general, there exists the possibility of using those costs to subsidize the polluters in their abatement efforts. Public funds could be given as outright subsidy, but this discussion will be confined to the type of subsidy that has been most frequently proposed—the tax incentive.¹¹ Since a tax incentive is at the cost of lower government revenues, the incentive, properly computed and administered, could be made to result in a tax loss to the government equal to the cost of pollution *control*—i.e., the method of abatement I have been discussing heretofore. Assuming the government wishes to maintain its revenues at the level that would prevail in the absence of the tax incentive, other taxes would be increased and the net position of the public in general would be unchanged. In the one instance the public pays through increased costs of the goods and services it purchases, in the other it pays through increased taxes.

Now it is unlikely that the incidence of the shifted tax burden

on the public will be distributed in the same fashion as the direct costs of abatement. We have, therefore, another trade-off in the decision between the two routes of obtaining abatement. Here the social advantages or disadvantages of the shifted tax incidence must be compared with those of the direct cost incidence. The use of numerical values is impossible; the most that can be done is to use what aid to judgment can be obtained from the theoreticians in fiscal and welfare economics. Once again, however, the important point in the present context is not the precision with which the decision (between control and incentive) can be made but the fact that if it is to be done at all rationally, the trade-off must be recognized and in some fashion taken into account.

If the fiscal route is followed, there are further trade-offs in the application of the incentive. Suppose, for example, the incentive is offered in the form of a tax credit or accelerated depreciation to be allowed for investment in abatement facilities. Abatement costs involve both capital and operating costs, but since such incentives would apply only to capital, they would tend to result in a disproportionate use of capital in abatement efforts. Thus, if a polluter had his choice between the use of low-sulfur fuel or stack gas treatment he would be more inclined to opt for the latter, which would increase his cash flow, than he would in the absence of the incentive.

The same government study previously mentioned also investigated this subject and, noting among other things that fuel substitution (e.g., the use of low-sulfur fuel) was the indicated least-cost alternative in more than 60 percent of air pollution abatement, concluded that "tax writeoffs are not needed nor are they a desirable form for offering further assistance to industry."¹² Tax incentives, in other words, would not stimulate use of the lowest cost abatement technique. This judgment was no doubt influenced by the recognition that the use of tax incentives for pollution abatement is politically undesirable because it increases the pressure for similar treatment for other worthwhile causes such as education and housing. At this point we are back to where we started—the trade-offs we must consider because of our limited means and the many demands on those means.

CONCLUSION

Shelley has written, "one wandering thought pollutes the day." Let me conclude before I become the cause of any such pollution.

Again, it must be emphasized that to lay stress on the horrendous data and measurement difficulties involved in the application of cost-benefit analysis to the trade-offs is not to suggest that such analysis is useless and should therefore be avoided or by-passed. It is essential that costs and benefits, however defined, be compared if pollution abatement is to be accomplished rationally, and it is unavoidable that such comparison be made if abatement is to be accomplished at anywhere near the least possible cost. It is urged that given the numbers problem, cost-benefit analysis be used in a pragmatic, not formulary fashion.



FOOTNOTES

* Director, Washington Office, National Economic Research Associates, Inc. This paper was presented at the Annual Meeting of the American Physical Society, New York, New York, February 4, 1969.

¹ Put more elegantly, this proposition is contained in the following statement: "... the job of the formulator of air pollution control policy is to bring about that correspondence between individual and collective welfare—however defined—which is lacking because the individual cannot or will not be operationally cognizant of the connection between certain of his means of achieving and maintaining his objectives and the achievement and maintenance of certain objectives for the collection of individuals." (T. D. Crocker, "Some Economics of Air Pollution Control," *Natural Resources Journal*, April, 1968, pp. 237 f.)

² Coordinating Committee on the Economic Impact of Pollution Abatement, "Report of the Working Committee on the Secondary Impact of Air Pollution Abatement," December 15, 1967, p. 7. Cf also H. Perry and J. A. De Carlo, "The Search for Low-Sulfur Coal," IEEE-ASME Joint Power Conference, Denver, September 18–21, 1966.

³ The gas industry is, to be sure, regulated, but this merely introduces a time lag.

⁴ *Mechanical Engineering*, August, 1965.

⁵ Working Committee on Economic Incentives, "Cost Sharing with Industry?" Summary Report (Revised), November 20, 1967, p. 12.

⁶ For a discussion of the measurement problem see A. V. Kneese, *Economics and the Quality of the Environment—Some Empirical Experiences*, Resources for the Future, Inc., Reprint No. 71, April, 1968.

⁷ *Clean Air News*, February 13, 1968, pp. 2 f.

⁸ P. H. Gerhardt, "Air Pollution Research Needs for Improved

Economic Analysis," Annual Air Pollution Control Association Conference, Cleveland, June 12, 1967.

⁹ H. O. Nourse, "The Effect of Air Pollution on House Values," *Land Economics*, May, 1967, pp. 181-189.

¹⁰ Working Committee on Economic Incentives, *op cit.*, pp. 19-25.

¹¹ The Internal Revenue Code of 1954, §169, as amended by the Tax Reform Act 1969, allows a taxpayer to amortize a portion of the cost of its investment in qualified pollution control facilities over a five-year period. (Editor's note.)

¹² Working Committee on Economic Incentives, *op. cit.*, pp. 27, 29.